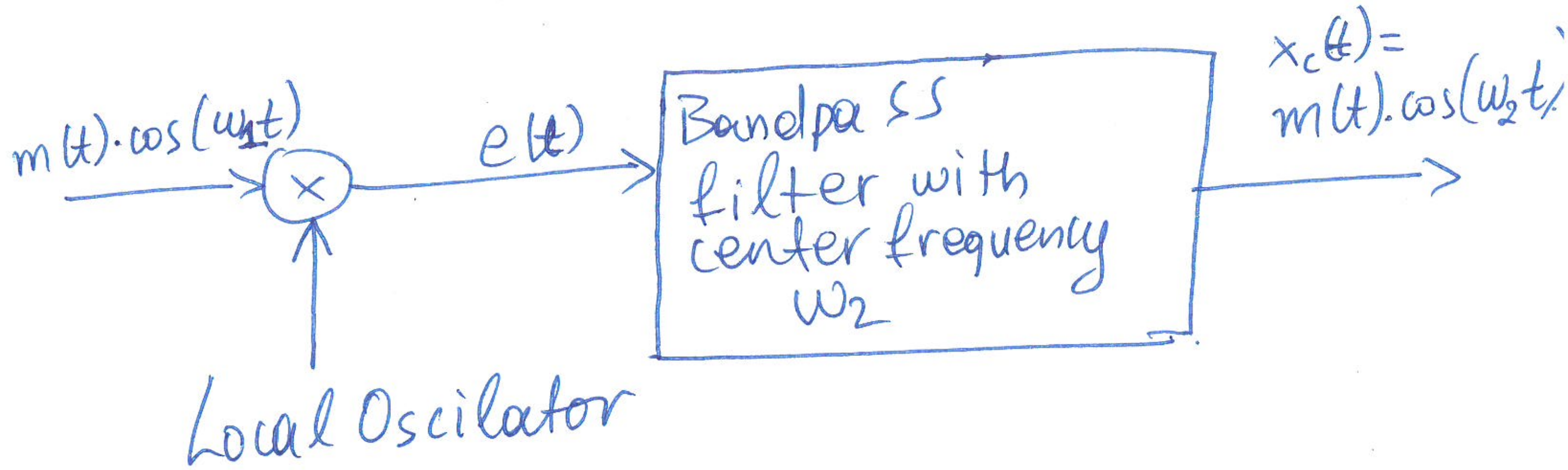
Frequency Translation & Mixing



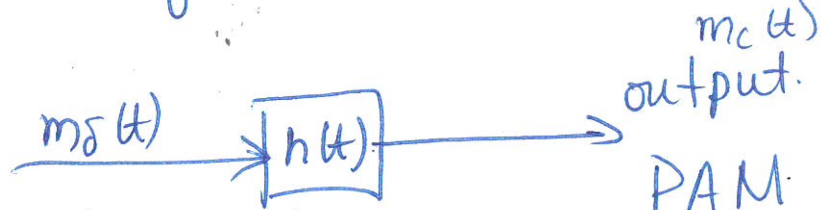
$2\cos(\omega_1 \pm \omega_2)t.$

Pulse Modulation

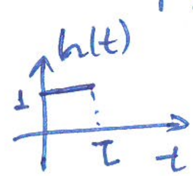
- amplitude (PAM)
- width (PWM)
- position (PPM)

message signal: $m(t)$

samples: $m_\delta(t) = m(nT_s) \cdot \delta(t - n \cdot T_s)$



$$h(t) = \Pi\left(\frac{t - \frac{1}{2}\tau}{\tau}\right)$$



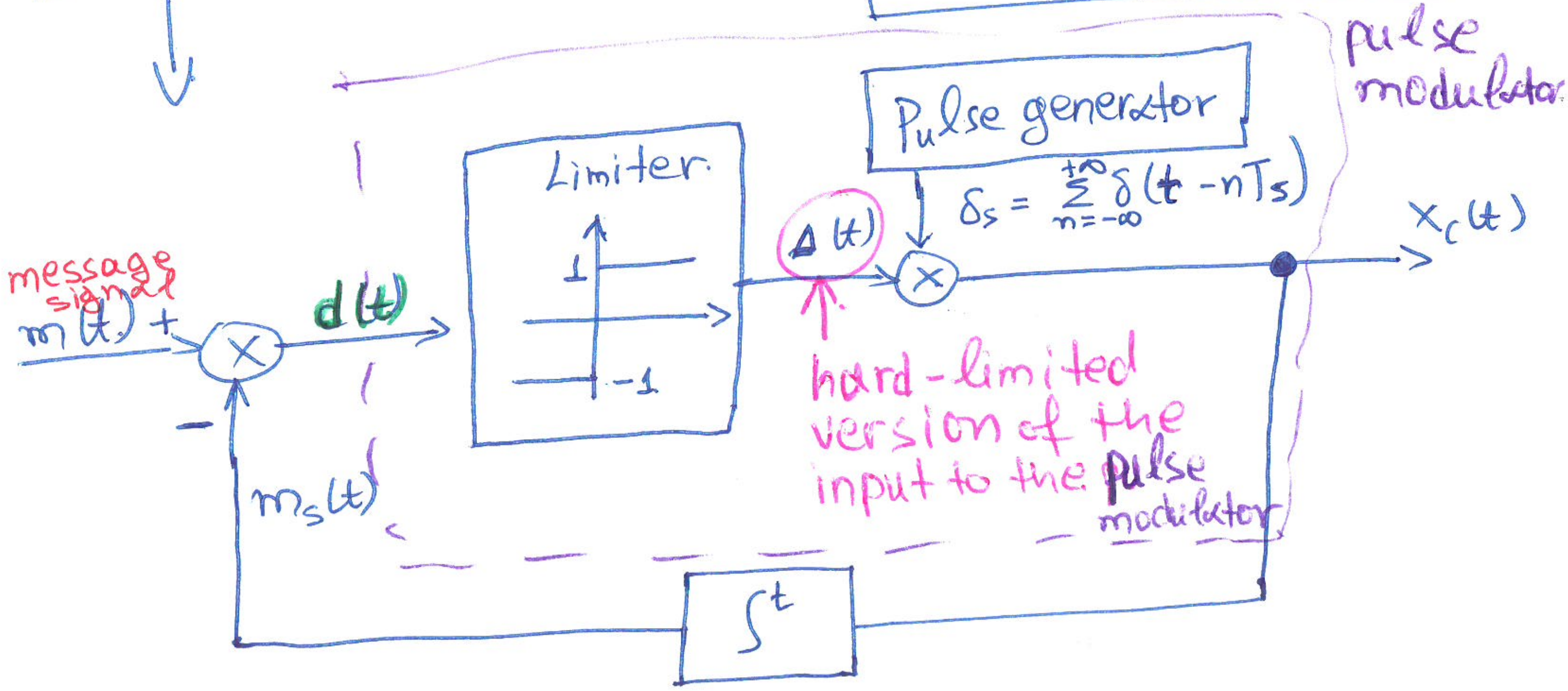
PAM waveform:

$$m_c(t) = m_\delta(t) * h(t)$$
$$= m(nT_s)\cdot \Pi\left(\frac{(t-nT_s)+\frac{1}{2}\tau}{\tau}\right)$$

Digital Pulse Modulation

Delta Modulation

Pulse Code Modulation



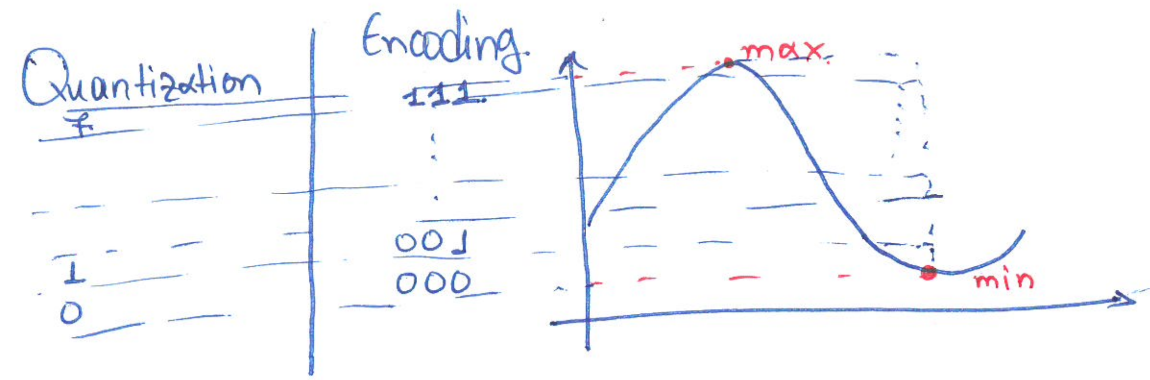
$$d(t) = m(t) - m_s(t)$$

$$x_c(t) = \Delta(nT_s)\cdot\delta(t-nT_s)$$
$$m_s(t) = \Delta(nT_s)\cdot\int^t \delta(x-nT_s)\,dx$$

Pulse Code Modulation

$m(t) \rightarrow$ Sampler $\rightarrow$ Quantizer $\rightarrow$ Encoder $\rightarrow$

e.g.



$q = 2^{n}$ ← length of word

Time - Division Multiplexing

1 message signal. (1 user transmitting) / timeslot

Angle-Modulation Techniques

PM FM.

General signal: $x_c(t) = A_c \cos[2\pi f_c t + \phi(t)]$

Instantaneous phase

$$\theta(t) = 2\pi f_c t + \phi(t)$$

phase deviation

Instantaneous frequency

$$f(t) \triangleq \frac{1}{2\pi}\frac{d\theta(t)}{dt}$$

$$= f_c + \frac{1}{2\pi}\frac{d\phi(t)}{dt}$$

frequency deviation

Phase Modulation (PM)

$$\phi(t) = K_p \cdot m(t)$$

Frequency Modulation (FM)

frequency deviation constant

$$\frac{d\phi(t)}{dt} = \underbrace{K_f}_{=2\pi f_d} \cdot m(t)$$

phase deviation

$$\phi(t) = K_f \cdot \int_{t_0}^{t} m(a)\,da + \phi_0$$

<u>Output of the phase modulator</u>

$$x_c(t) = A_c \cos[2\pi f_c t + k_p m(t)]$$

<u>Output of the frequency modulator</u>

$$x_c(t) = A_c \cos\left[2\pi f_c t + 2\pi f_d \cdot \int_{t_0}^{t} m(a)\,da + \phi_0\right]$$